Comment on 'Symmetrical Temperature-Chaos effect with Positive and Negative Temperature Shifts in a Spin Glass'.

In a very interesting paper, Jönsson, Yoshino and Nordblad[1] have shown that the effect of small temperature shifts on the aging behaviour of an Heisenberg-like spin glass could be interpreted quantitatively using the ideas of temperature chaos and overlap length. In this comment, we show that the same analysis can be performed in a case where temperature chaos is known to be irrelevant, weakening the main conclusion of Ref.[1].

As now well established, aging at low temperatures T in spin glasses is associated with the slow growth with time t of a coherence length, $\ell_T(t)$. This length can be measured in simulations, but can also be inferred from experimental data, using plausible assumptions, leading to a rather consistent determination of $\ell_T(t)$. "Cumulative aging"[1] means that the same coherence length grows at different temperatures, although at different rates. In this case, the value of $\ell_{T_i}(t_w)$ after staying a certain time t_w at a first temperature T_i serves as the 'initial condition' for the growth of ℓ after a temperature shift.

Rejuvenation effects, on the other hand, demonstrate that cumulative aging cannot be the only story in spin glasses. The "temperature chaos" scenario postulates that typical equilibrium configurations in a spin glass at two temperatures differing by ΔT are strongly correlated only up to the "overlap length", $\ell_{\Delta T}$, beyond which these correlations rapidly decay to zero. From scaling arguments, one expects $\ell_{\Delta T} \sim |\Delta T|^{-1/\zeta}$, with $\zeta \approx 1$ for the Ising spin glass. If this scenario holds, one expects that the initial condition for the growth of ℓ after a temperature shift, as encoded by an effective length $\ell_{\rm eff}$, will obey the following scaling form:

$$\frac{\ell_{\rm eff}}{\ell_{\Delta T}} = F\left(\frac{\ell_{T_i}(t_w)}{\ell_{\Delta T}}\right), \tag{1}$$

with $F(x \ll 1) = x$ (cumulative aging) and $F(x \gg 1) = 1$ (temperature chaos). Rejuvenation, i.e. deviations from cumulative aging, can thus be accounted for by temperature chaos. The verification of Eq. (1) using experimentally determined values of ℓ_{T_i} and $\ell_{\rm eff}$ for different ΔT and t_w is the central result of Ref.[1], thereby providing strong support for the temperature chaos scenario and a numerical value for the chaos exponent for the AgMn spin-glass, $1/\zeta \approx 2.6$. In the above argument, one assumes from the start that rejuvenation is induced by temperature chaos, and finds *self-consistent* results.

However, other scenarii have been proposed in the literature to explain rejuvenation effects, such as the progressive freezing of smaller and smaller length scale modes[2,3]. In this respect, we recently demonstrated in a numerical simulation of the 4d Ising spin glass that strong rejuvenation effects can be observed in conditions where the overlap length is *independently* observed to be much larger than all relevant length scales[2].

To understand these contradictory results[1,2], we have reproduced the protocol of Ref.[1] in an extensive new series of simulations, and followed the very same steps to determine the length scales $\ell_{T_i}(t_w)$ and $\ell_{\rm eff}$. Although we do know that all dynamic length scales in our simulations are ≤ 5 and that the overlap length is much larger (probably larger than 20), we tried to rescale all our results using Eq. (1). Surprisingly, as shown in Fig. 1, this works very well with the expected value $\zeta \approx 1$. Rejuvenation results then in our case in the appearance of a *fictitious* overlap length, $\ell^F_{\Delta T}$. This shows that although suggestive, the analysis of Ref.[1] cannot be viewed as definitive evidence for temperature chaos.

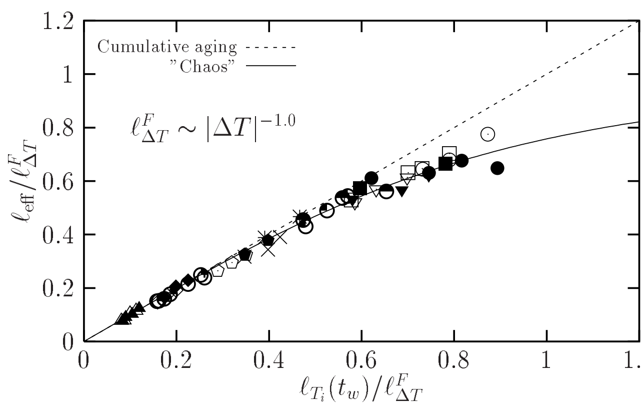

FIG. 1. Test of Eq. (1) for a series of "twin experiments" in the 4d Gaussian Ising spin glass strictly following protocols and analysis of Ref.[1]. 56 shift experiments are presented with $T_i/T_c \in [0.4, 0.9]$, $\Delta T/T_c = 0.05,\ 0.1,\ 0.2,\ \cdots,\ 0.5$, $t_w \in [80, 57797]$. System size is $L = 25 \gg \ell_T(t)$. $\ell_{\rm eff}$ was defined from the maximum of $\partial C(t+t_w, t_w)/\partial t$, where C is the spin autocorrelation function (instead of TRM) and growth laws $\ell_T(t)$ taken from Ref.[2]. The exponent ζ of the fictitious overlap length $\ell^F_{\Delta T}$ is chosen to collapse *all* our data.

Simulations were performed on OSWELL at the Oxford Supercomputing Center, Oxford University, UK.

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